



***4th Integrated CNS Technologies
Conference & Workshop***

***Aviation Communications
Emulation Testbed***

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Glenn Research Center

at Lewis Field



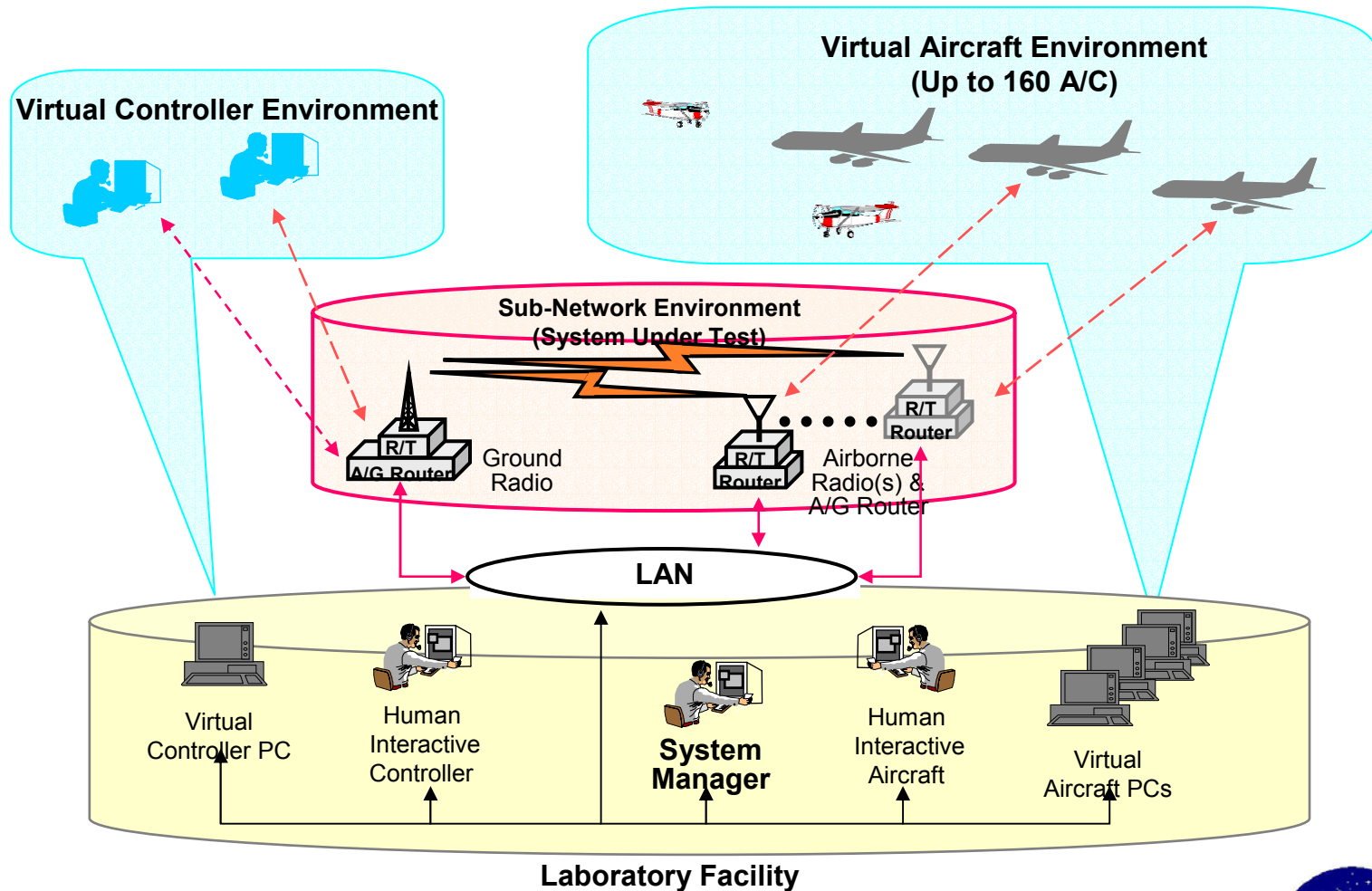
Outline

- Background
- Testbed Concept
- Virtual Aircraft & Controller (VAC) Builds
 - Limited CM & CPDLC
 - 160 Aircraft CM & CPDLC
 - ADS-B & TIS-B
- Future Capability
- Summary

Background

- Impact of data link traffic loads on the National Airspace System (NAS) communications infrastructure is not well known.
- GRC's AC/ATM project has supported the incremental development of an emulation and test facility to study:
 - Data link interactions
 - Capacity of the NAS infrastructure to support the data communications requirements of various applications.
- Virtual Aircraft and Controller (VAC) Testbed provides a means of observing the operation of large-scale aeronautical data link communications using different subnetworks.

Comm Emulation Testbed Concept



Evolutionary Development

- 2000 – VAC Build A
 - 5 human interactive aircraft and single human interactive controller
 - ATN applications: CM & CPDLC
 - 12 CPDLC messages
- 2002 – VAC Build B
 - Human interactive aircraft and controllers
 - 160 Autonomous (scripted) aircraft and multiple autonomous controllers
 - ATN applications: CM & CPDLC
 - 105 CPDLC messages

Evolutionary Development

- 2003 – VDL Mode 2 communications equipment
 - Emulates aircraft Communications Management Unit
 - 1 ground and 4 aircraft VDL Mode 2 radios
- 2004 – VAC Build C
 - Adds ADS-B & TIS-B capability
 - 40 aircraft transmit ADS-B
 - 160 aircraft receive TIS-B
- Future – Active radio frequency environment capabilities of Joint Communications Simulator

Aircraft/Controller Functionality

GUIs

- Emulates Generic ATC Workstation
- Emulates MCDU for CPDLC
- Emulates CDTI for ADS-B & TIS-B
- Message Alerting & Display
- Message Selection & Composition
- Actions Taken Indicators
- “Free Play” CPDLC with ATSP
- Controller Display has Full Data Blocks

Human Interactive Aircraft & Controller

- “Human in the Loop” Testing
 - User Configuration, Initialization and Experiment
 - Responses Based on Received Message
- Monitored by System Manager
- Communications:
 - ATN Compliant (TP4/CLNP)
 - Between Interactive Controller and Aircraft via ATN Subnetwork
 - With System Manager
- Automatically Saves all Configuration and Experiment Data

ADS-B

- Mode Status Reports
- State Vectors

TIS-B

- Target Reports

CPDLC Messages

- ICAO SARPs Compliant CPDLC
 - 69 Uplink Messages
 - 36 Downlink Messages
- ADLS Baseline 1 Message Set
- Message Element Concatenation

Autonomous Aircraft & Controller

- Up to 160 Aircraft Emulated
- Script Driven
 - Timed Aircraft Requests
 - Timed Controller Instructions
 - Automated Response to Requests based on Received Message
- Managed, Controlled and Monitored by System Manager
- Communications:
 - ATN Compliant (TP4/CLNP)
 - Between Aircraft and Controller via
 - ATN Subnetwork for CPDLC
 - Another Subnetwork for ADS-B & TIS-B
 - With System Manager
- Automatically Saves all Configuration and Experiment data

System Manager Functionality

Autonomous Operations

- Initiated and Controlled by System Manager
- Not Affected by Human Interactive Operations

System Initialization

- Distributes Configuration Data to Workstations

Data Transfer

- Online - Real Time Status
- Offline - Post-Experiment File Transfer of Aircraft and Controller Files for Data Reduction

System Control

- Start and Stop Experiment

Experiment Scripting

- User Constructs Scenarios and Scripts
- Supports Aircraft Departure to Arrival Profile
- Supports Background Loading with CPDLC Messages
- ATN SARPs Compliant Messages
- RTCA DO-242A Compliant ADS-B Messages
- RTCA DO-286 Compliant TIS-B Messages
- Scenario & Script Libraries
- Prints Scenarios & Scripts in Human Readable Form

Monitor

- Communications Delay Measurements
- Communications Status of Each Workstation
- Error Message Status

Script Monitoring and Display

- Monitor Scenario Progress on System Manager Display
- Monitor Status of Individual Autonomous Aircraft Script Execution

Data Reduction

- Processes Data for use in Reporting

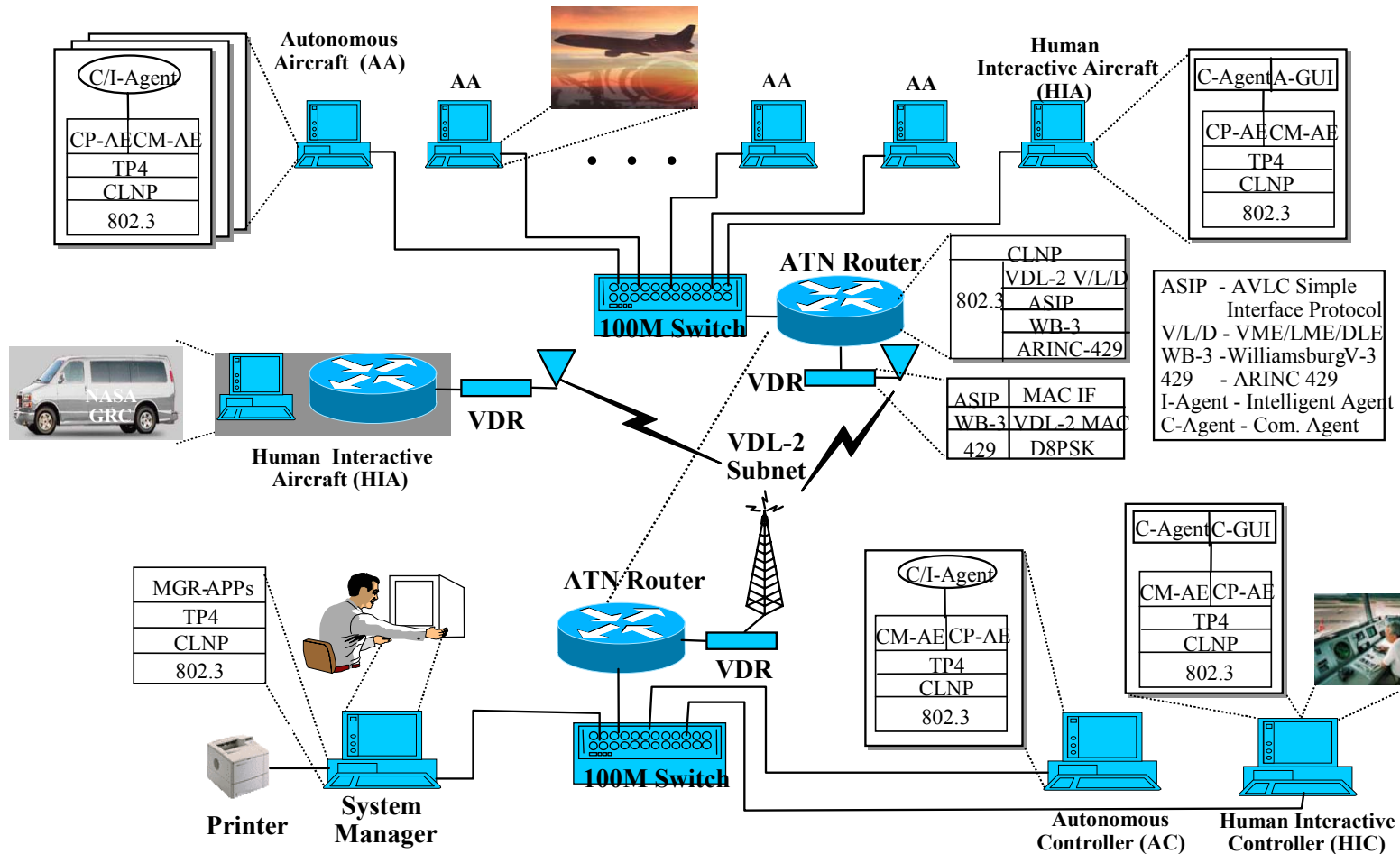
System Configuration

- Select Workstations for Experiment
- Select Controller Workstations
- Assign Aircraft for Each Workstation
- Assign Script to Each Aircraft
- Assign 24-bit Address to Each Aircraft
- Assign Facility Designation to Controller
- Assign Unique NSAPs to Each Aircraft and Controller
- Enter Experiment Start and Stop Times

Reporting

- User Selectable Reports
- Display, Save, and Print Reports
- On-line Reports
 - End-to-End Delay
 - Error Messages
- Off-line Reports
 - Experiment Summary
 - Message Transmitted List
 - Message Received List
 - Master Message List
 - End-to-End Delay
 - Error Messages
 - Related Events

CM & CPDLC Comm Architecture



Aircraft Display



En Route Controller Display



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Human Interactive Exchanges - ATN

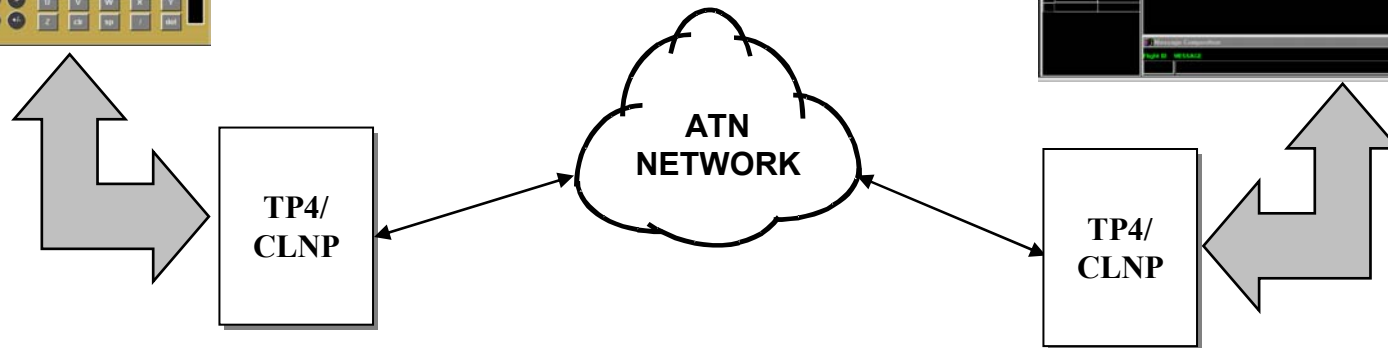
Aircraft Display



Features

- Emulates Generic MCDU/Controller
- SARPs Compliant Baseline 1 CPDLC message set
 - 105 Messages
- Message Element Concatenation
 - 5 Message Elements
- “Free Play” CPDLC between Aircraft & Controller
- Message Alerting & Display
- Message Selection & Composition

Enroute Controller Display



Manual Message Input and Response

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Performance Measurements

- Testbed provides means to measure end-to-end delay associated with using ATN applications (CM & CPDLC) over various subnetworks.
- Testbed can provide insight into number of data link equipped aircraft that can operate safely on a single VDL-2 frequency.
- Testbed can generate the data link messages associated with up to 160 separate aircraft flying realistic flight profiles.
- GRC can perform experiments using the Testbed to estimate the number of aircraft that can operate on a single frequency while satisfying the FAA's delay requirements.

CPDLC Performance Requirements

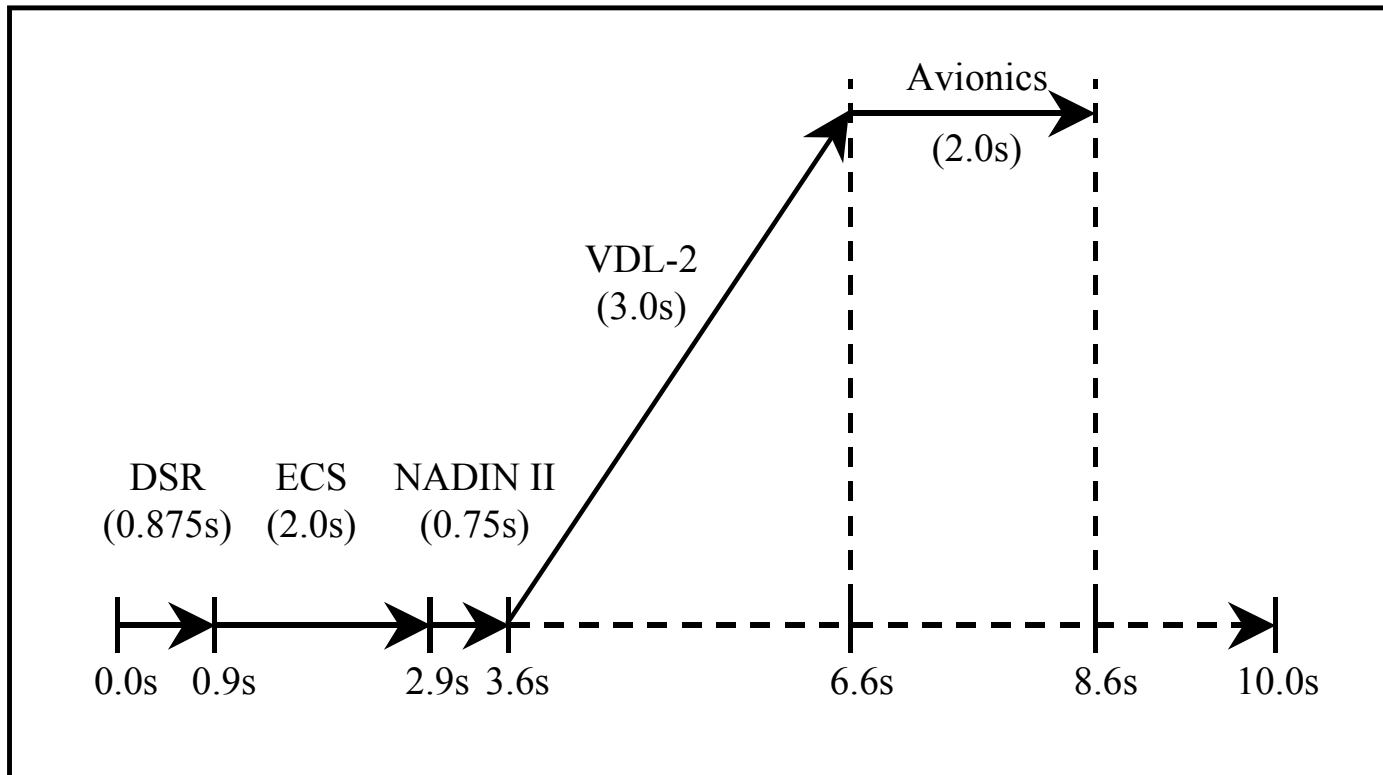
FAA Requirements for End-to-End Transfer Delay

Domain	Mean End-to-End Transfer Delay	95% End-to-End Transfer Delay	99.996% End-to-End Transfer Delay
Terminal	5 sec	8 sec	12.5 sec
En Route	10 sec	15 sec	22 sec

Source: FAA Initial Requirements Document for Controller Pilot Data Link Communications (CPDLC) Services, 22 Jun 98

End-to-End Delay - CPDLC IA Budget

FAA CPDLC-IA Specification for En Route Delay



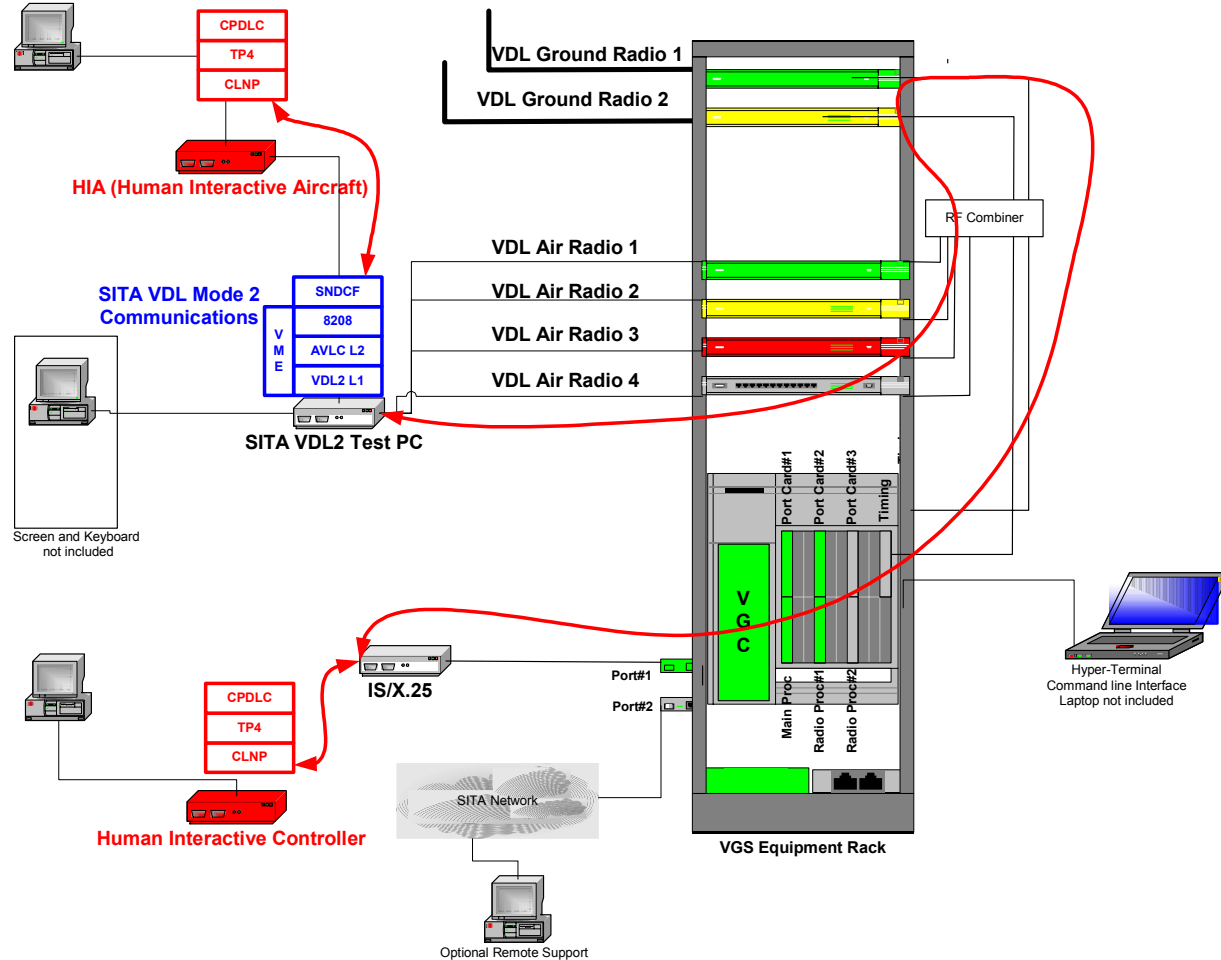
Mean Transfer Delay Time Budgets

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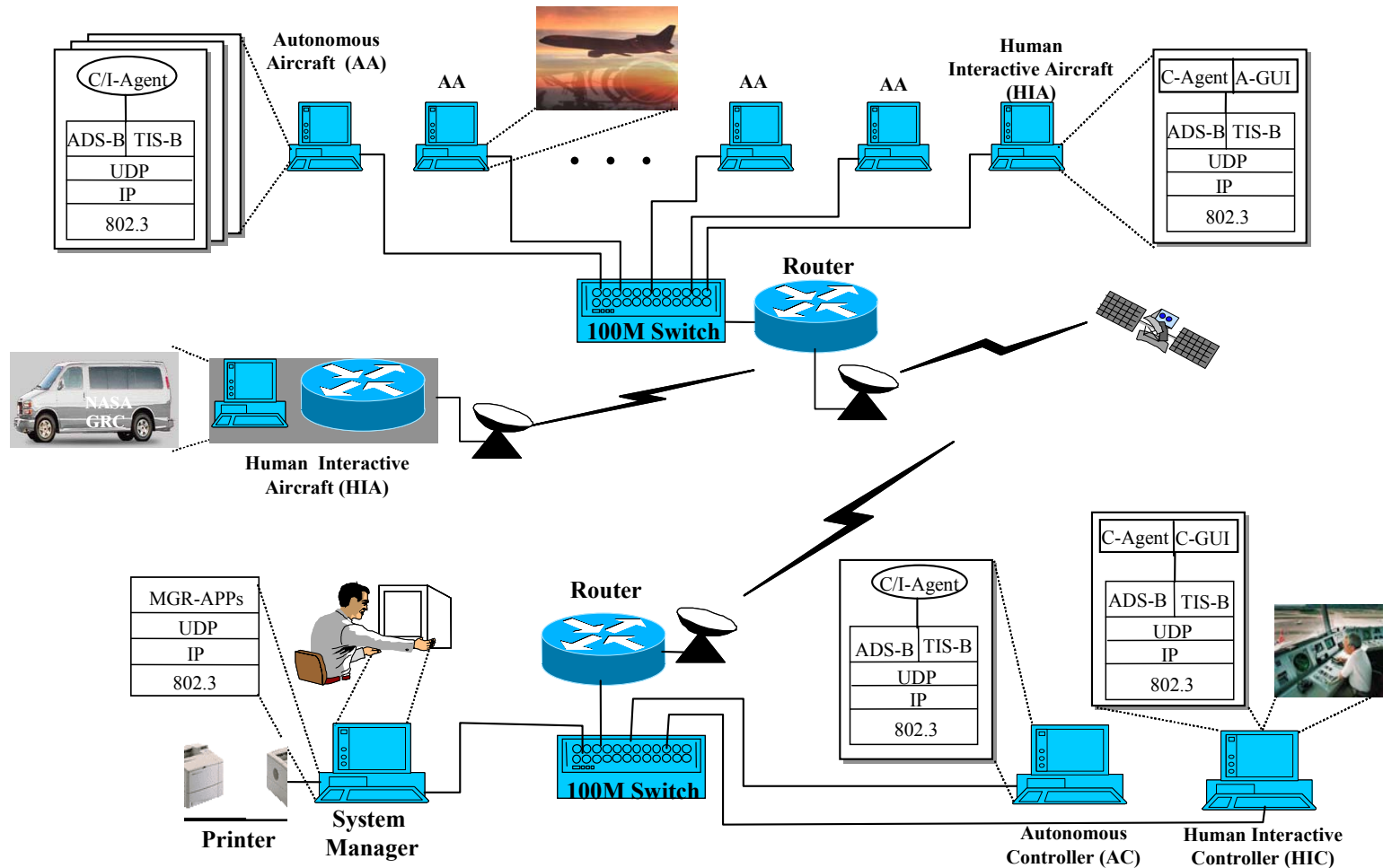
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VDL-2 Comm Equipment



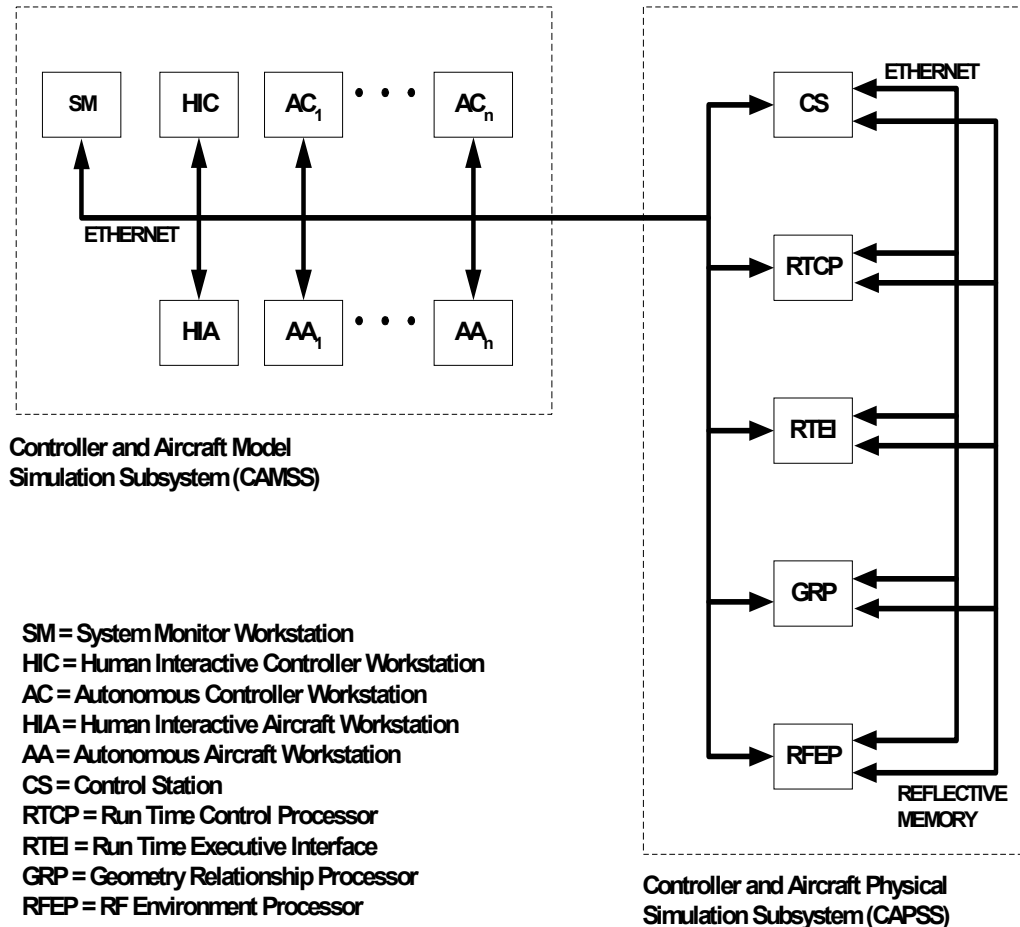
ADS-B & TIS-B Comm Architecture



Future

- Create an environment that supports multiple communications systems and frequencies.
- Enhance the realistic communications environment of the testbed by adding a physical layer emulation capability.
- Add the Joint Communications Simulator (JCS) capability to the testbed as a physical layer modeling tool.
- Use the testbed to validate communications models and concepts.

Testbed with Joint Comm Simulator



Summary

- GRC's large-scale CPDLC emulation testbed provides the capability to study the impact of data link traffic loads on the NAS communications infrastructure.
- End-to-end ATN message (CM and CPDLC) emulation provides the means to assess the number of aircraft that a subnetwork can support and meet the FAA's performance goals.
- The addition of VDL Mode 2 subnetwork communications systems adds another dimension of realism to the analysis toolset.

Summary

- The implementation shortly of an ADS-B and TIS-B message emulation capability will support studies on new surveillance applications being added to the NAS.
- The addition of the Joint Communications Simulator will allow the testing of new communications hardware and systems.

Credits

- Advance Communications for Air traffic Management Program (AC/ATM)



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